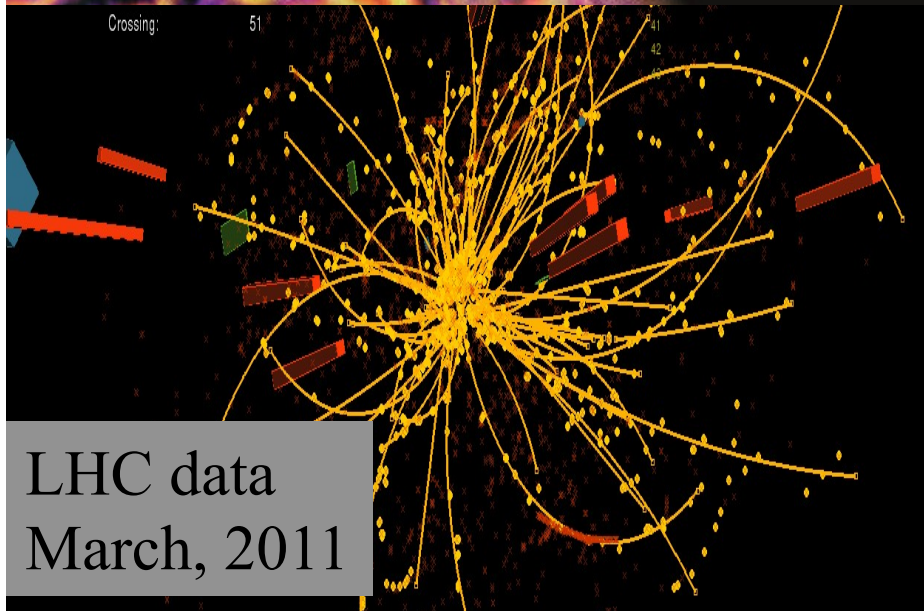


Quarks and the Cosmos

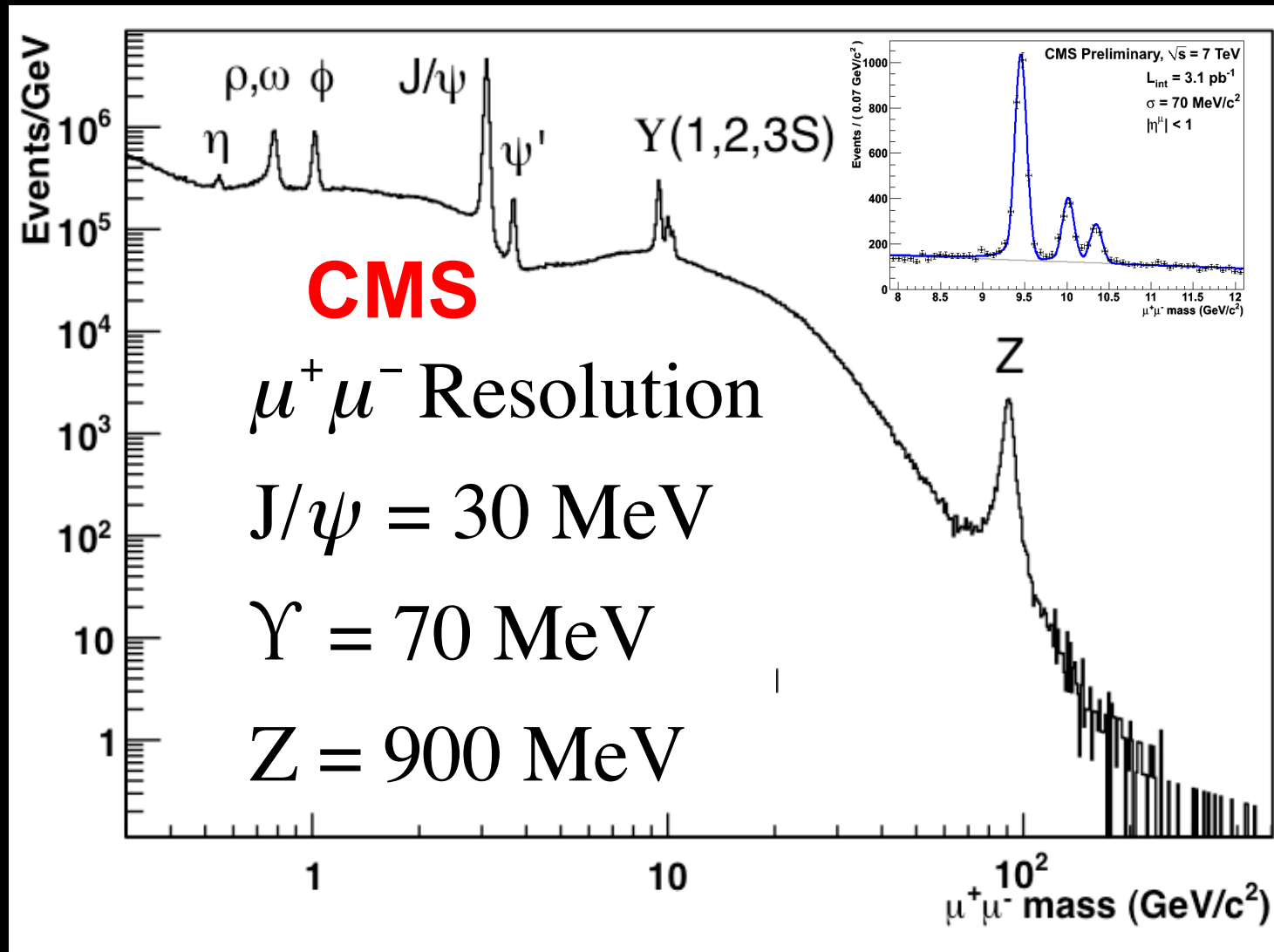


LHC: Higgs, SUSY
Dark Energy Program
Instrumentation

THE LARGE HADRON COLLIDER



A spectroscopists delight: CMS & ATLAS rediscovering the Benchmarks of the Standard Model



The Higgs

Searching for the mechanism of electroweak symmetry breaking, we seek to understand

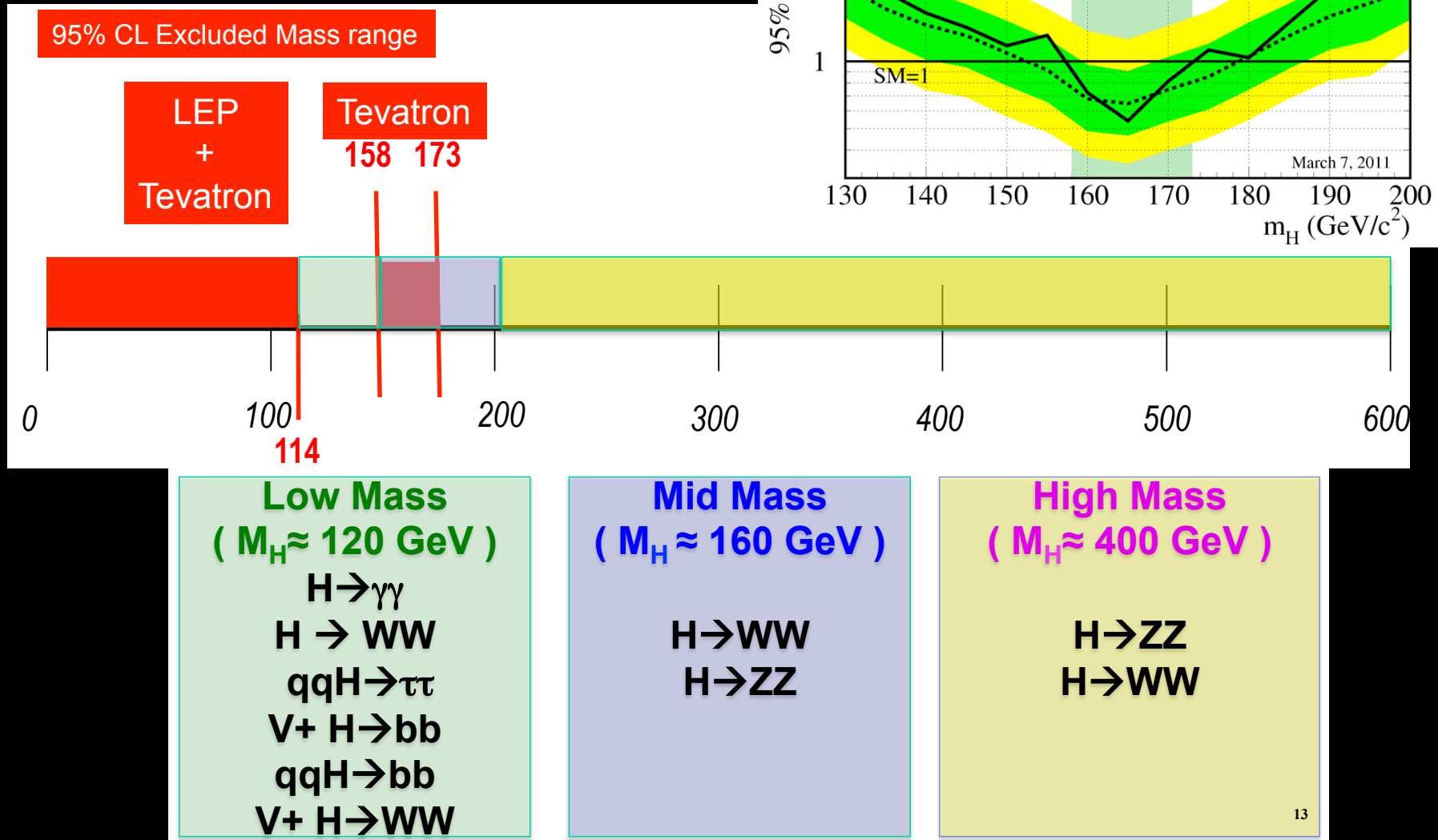
why the world is the way it is.

This is one of the deepest questions humans have ever pursued, and

it is coming within the reach of particle physics.

Slide adapted from talk by Chris Quigg

Higgs Search Landscape

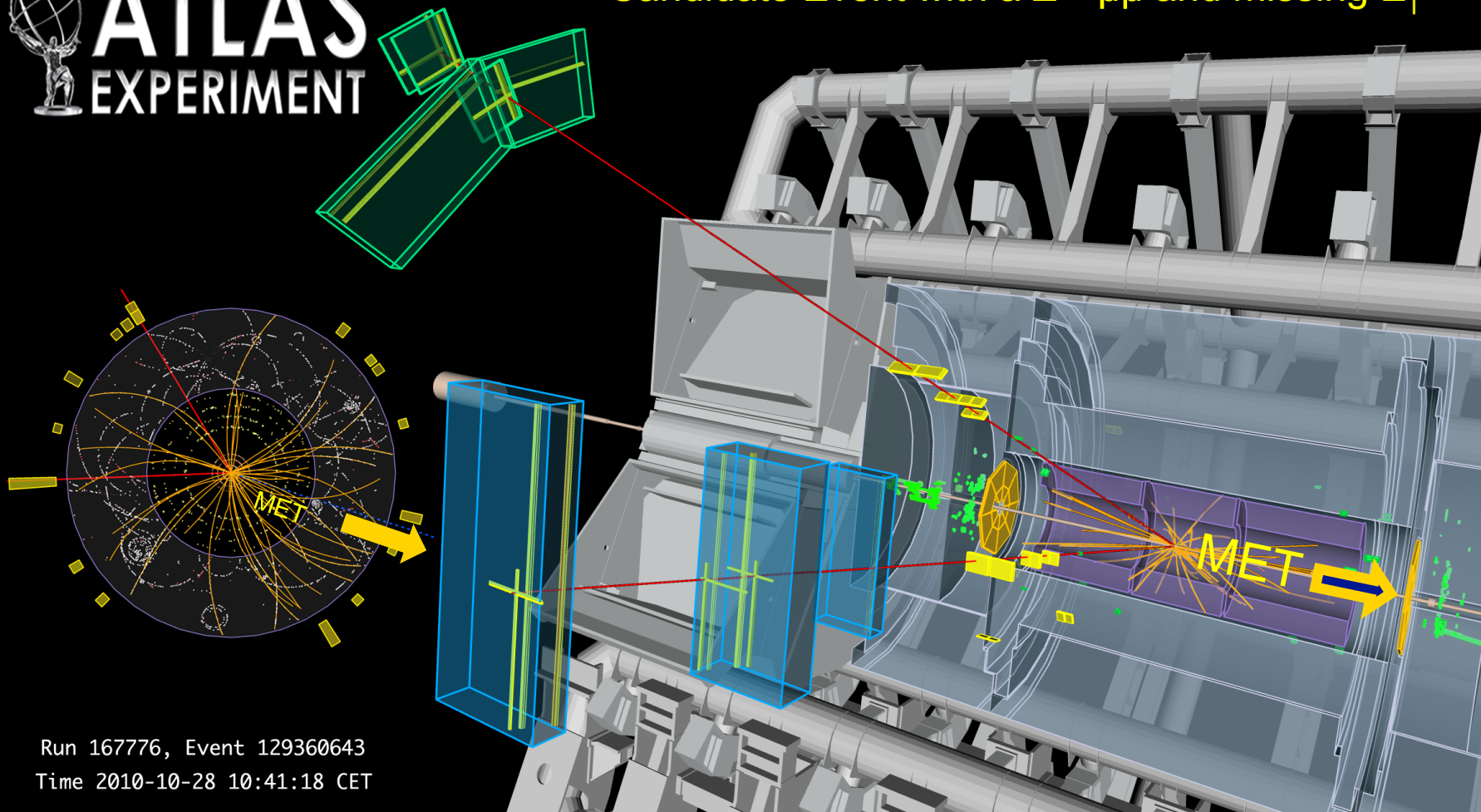


A $ZZ \rightarrow \mu\mu\nu\nu$ Candidate in ATLAS Data

$$M_{\mu\mu} = 94 \text{ GeV}, E_T^{\text{miss}} = 161 \text{ GeV}$$



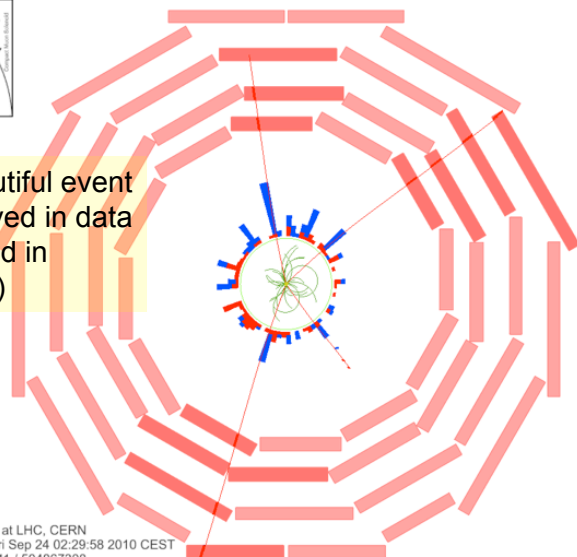
Candidate Event with a $Z \rightarrow \mu\mu$ and missing E_T



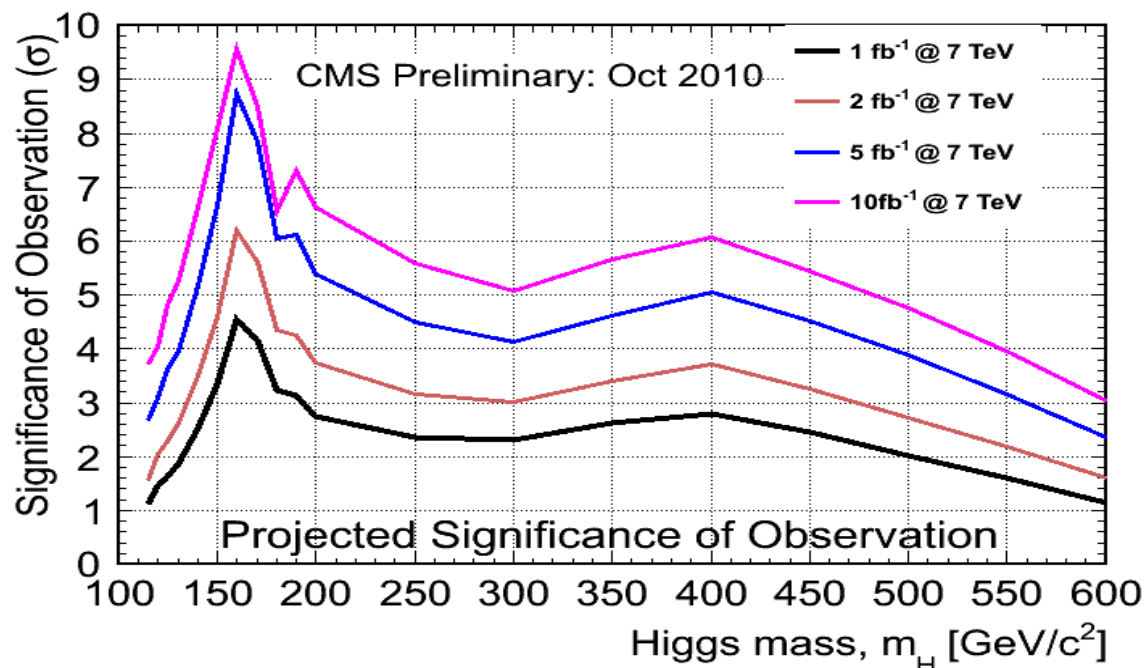
Run 167776, Event 129360643
Time 2010-10-28 10:41:18 CET



A beautiful event
observed in data
(walked in
early !)



CMS Experiment at LHC, CERN
Data recorded: Fri Sep 24 02:29:58 2010 CEST
Run/Event: 146511 / 504867308



Tevatron: proposed Run III, sadly, did not materialize. If Tevatron runs until Sept 2011 (10/fb) 2.4σ expected sensitivity 114 - 200 GeV ; 3σ at 115 GeV

2011-12 Run: **ATLAS + CMS:** 3σ discovery or 95% CL exclusion 114 - 600 GeV

If Higgs is found a major milestone final missing piece of SM. The end of the beginning of a ~30 year quest to understand electroweak symmetry breaking. Next stage: Is it really the SM Higgs? Determine properties couplings, spin, width etc. Is our simplest picture of the origin of mass correct or is electroweak symmetry breaking intertwined with beyond standard model physics? Both LHC and future lepton colliders will contribute

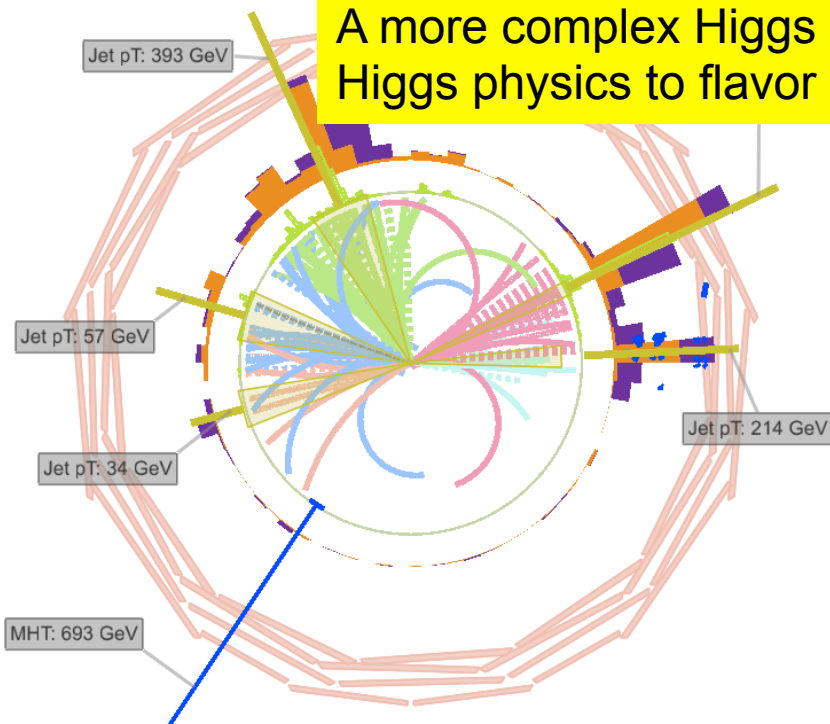


CMS Experiment a
Data recorded: Tue
Run/Event: 148953
Lumi section: 49

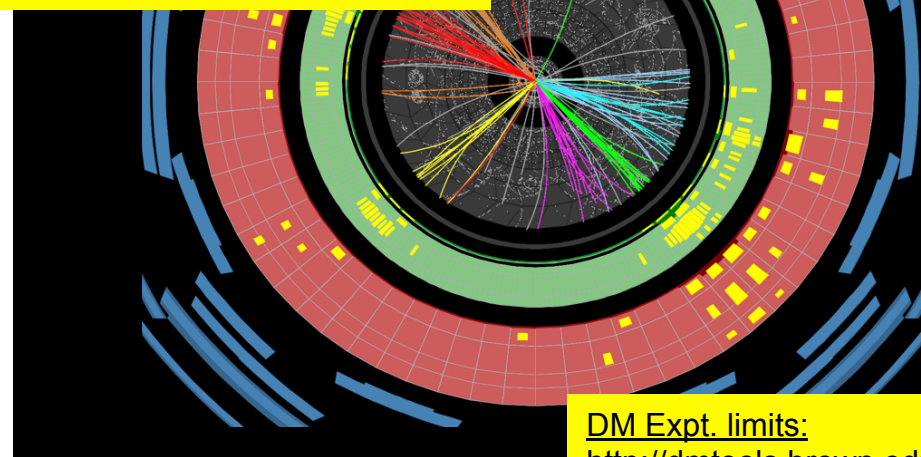
Supersymmetry

Leading candidate for physics beyond SM

A more complex Higgs sector and connects
Higgs physics to flavor physics and cosmology



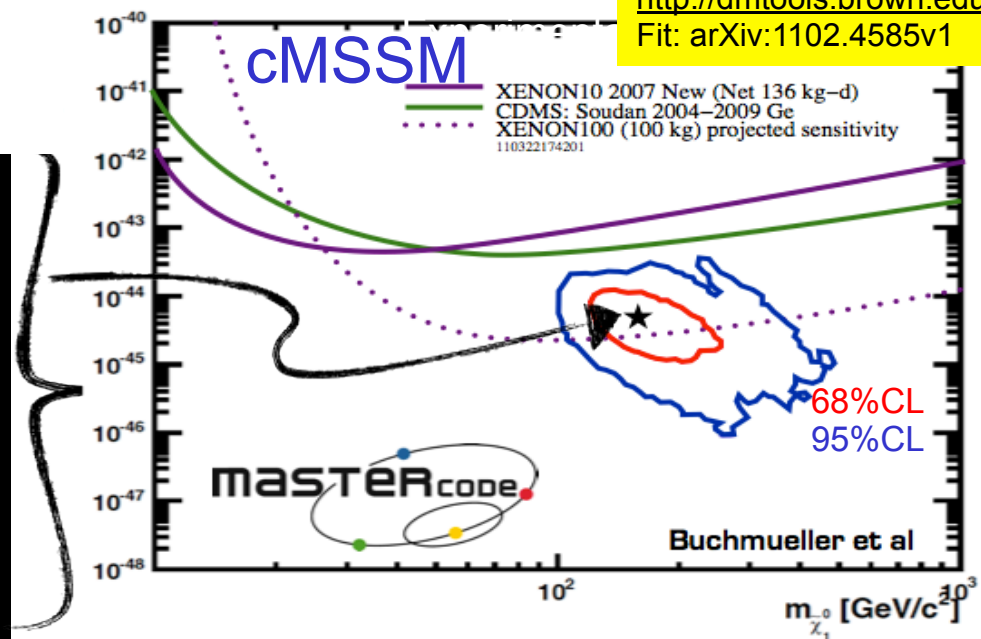
Run Number: 166198, Event Number: 100726931
Date: 2010-10-05 03:27:52 CEST



DM Expt. limits:
<http://dmttools.brown.edu/>
Fit: arXiv:1102.4585v1

Global Fit of SUSY :

- **Precision Particle Physics data**
 - Flavour observables (e.g. B-Physics, $g-2$)
 - Electroweak observables (e.g. m_t , m_W)
- Cosmology/astrophysical data**
 - Relic density (WMAP)
- LHC data**
 - Direct searches
 - (LHC limits exceed Tevatron)



Cosmic Frontier Fermilab Shipsey

Energy frontier: Given experimental evidence at LHC for physics beyond the Standard Model how can we determine the underlying theory?

Within the context of supersymmetry, qualitatively different models can give similar LHC signatures. Need more observables

Intensity frontier: B/K physics, ($\mu \rightarrow e \gamma$) ($g_\mu - 2$) important to sort between new physics scenarios

Analog: In a world of LEP/ Tevatron/LHC but no B factories we would not have confirmed CKM and sent KM to Stockholm!

To Cosmic Frontier: Within a SUSY scenario using the LHC data predict relic density, if consistent \rightarrow identified the particle responsible for dark matter (DM),
if overclose DM found at LHC not completely cosmologically stable
if underclose \rightarrow DM in the universe has at least 2 components one of which may not couple to LHC physics (example: axions)

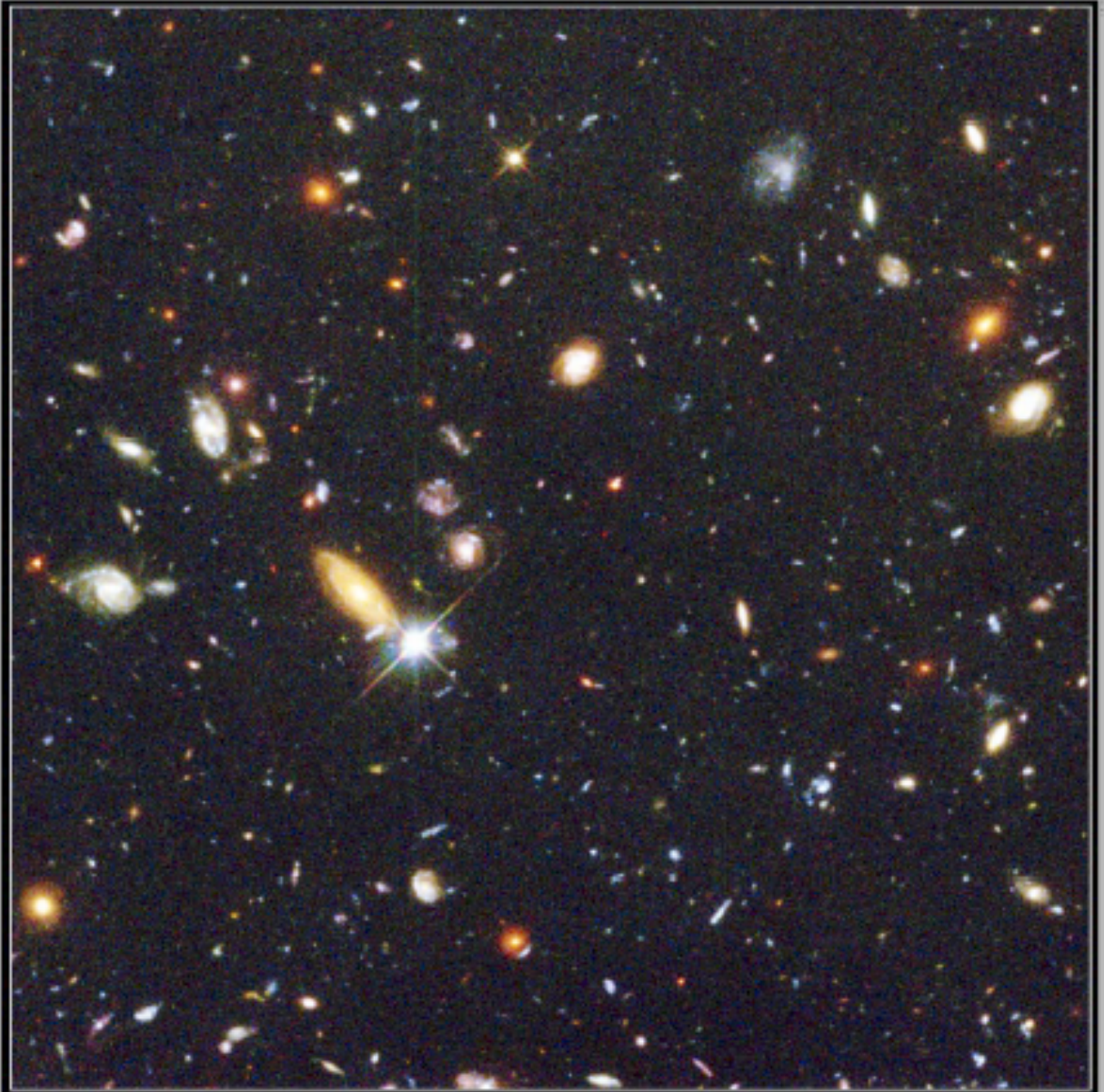
Hubble deep field

UNIVERSE
OF
GALAXIES

3000
here



100 billion
over entire
sky



Cosmic Frontier Fermilab Shipsey

Image sizes LSST, Moon, HST

PASAG (2009):

The panel recommends the formulation of a detailed plan for achieving a comprehensive and optimal dark energy portfolio under all funding scenarios. This plan should support projects whose science reach approaches astrophysical limitations for the 3 primary dark energy methods. Clearly Astro2010 is an essential component of this process.

Following ASTR2010:

- LSST preparing for NSF PDR and DOE CD-0/1.
- Status of the rest of the stage IV portfolio?
- Elucidation of Dark Energy requires global coordinated Stage IV program of requisite precision

HST



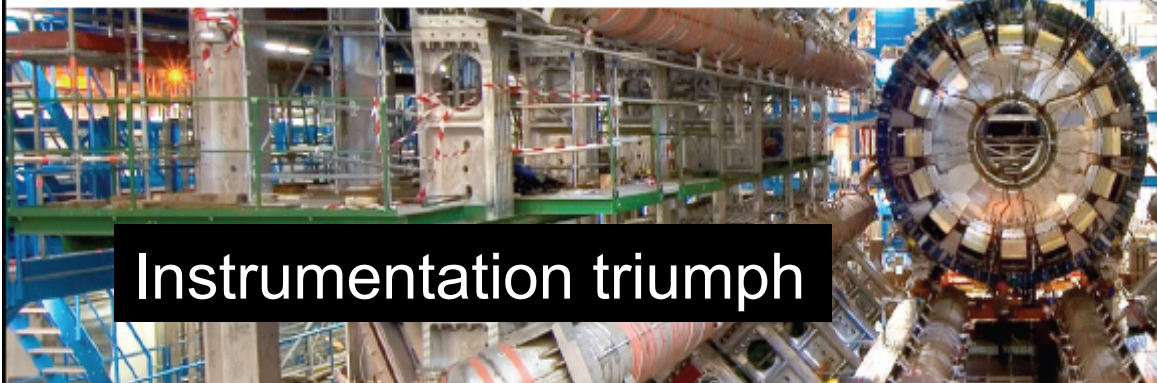
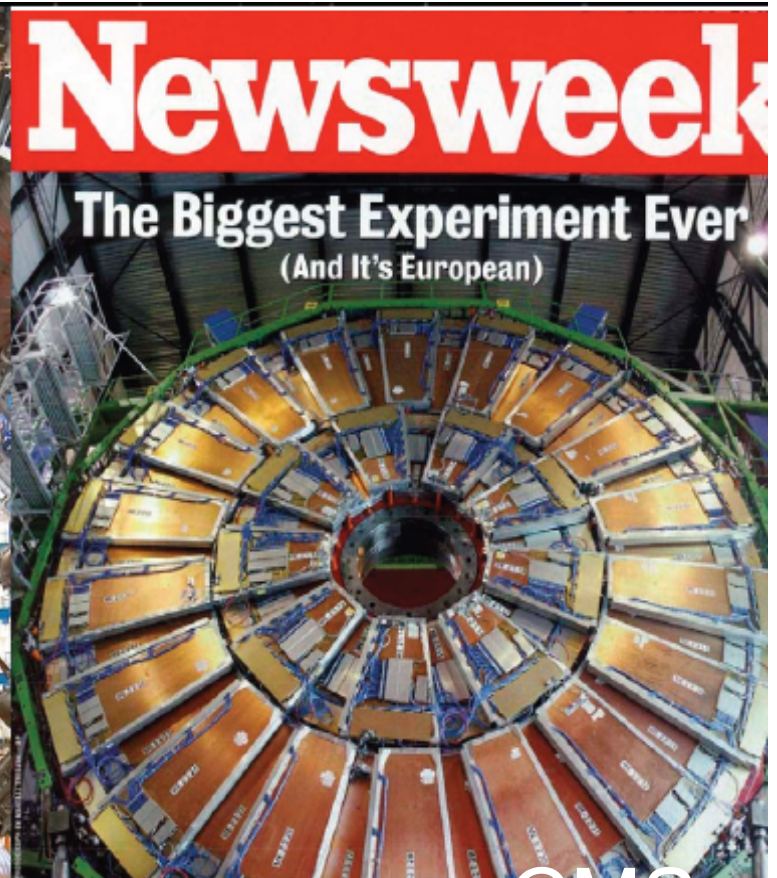
Particle Physics and Astrophysics: $1 + 1 = 3$

As astrophysical observations offer new opportunities to answer questions in fundamental physics, it is necessary to understand in sufficient detail the related astrophysical phenomena.

One need not be a particle physicist to study these phenomena, but particle physicists must ensure they are understood to the required precision to use them for solving some of the outstanding mysteries in particle physics.

The high standard of proof for new physics is not tied to technique – it is the same at both accelerators and telescopes – so the astrophysics investment is sometimes necessary to realize the particle physics benefit. Furthermore, the relationship is symbiotic: particle physicists have much to offer these important related fields of study and often have a major impact on them. We have much to learn from each other, and there is much we can do together. (PASAG).

Object	Weight (tons)
Boeing 747 [fully loaded]	200
Endeavor space shuttle	368
ATLAS	7,000
Eiffel Tower	7,300
USS John McCain	8,300
CMS	12,500



Instrumentation triumph

Instrumentation Challenge



ATLAS

DIGITAL CAMERAS THE SIZE OF CATHEDRALS



© 2007, 2008, 2009, 2010
Ian Shipsey

Taskforce on Instrumentation in HEP

= particle and particle astrophysics

- **From Universities**
 - Ian Shipsey*, Purdue
 - Marina Artuso, Syracuse
 - Ed Blucher, Chicago
 - Bill Molzen, Irvine
 - Gabriella Sciolla, MIT
 - Andy White, UT Arlington
- **From Laboratories**
 - Marcel Demarteau*, Argonne
 - David Lissauer, Brookhaven
 - David MacFarlane, SLAC
 - Greg Bock, Fermilab
 - Gil Gilchriese, LBNL
 - Harry Weerts, Argonne
- **Ex-officio**
 - Chip Brock, DPF (MSU)
 - Patty McBride, DPF (Fermilab)
 - Howard Nicholson, Mount Holyoke

Charge can be found at <http://www.dpfnewsletter.org/?p=425>

Will explore: creation/expansion of instrumentation schools

Creation of national post doc and GS instrumentation fellowships

Centers at the labs where university and lab scientists can access resources to develop new detector concepts & test them

Creation of a National Advisory Board for Instrumentation

Expanded links to industry/materials science/condensed matter physics/electrical and computer engineering/nuclear physics

Created Feb. 2011 Marcel Demarteau and IS (co-chairs)